

Research Article

Agriculture Landholding and Food Security in Terai Region of Nepal: A Case Study of Lakshmaniya Rural Municipality, Dhanusha District

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Abstract

Agriculture is the primary source of livelihood in Nepal's Terai region, which is widely recognized as the country's food basket. However, agricultural landholding size, parcel fragmentation, and household size influence household food sufficiency. This study examines the relationship between agricultural landholding patterns and household food sufficiency in Lakshmaniya Rural Municipality, Dhanusha District, Nepal. Primary data were collected from 396 randomly selected households, supported by two focus group discussions and four key informant interviews. Information was obtained on landholding area, number of parcels, family size, cropping intensity, agricultural inputs, and months of household food sufficiency. Descriptive statistics, correlation analysis, and multiple linear regression were used for data analysis. The average household food sufficiency was 9.83 months per year. Among 393 valid food-sufficiency responses, 8.91% of households reported food sufficiency for only three months, while 46.42% reported food sufficiency for 12 months or more. The average agricultural landholding was 0.78 ha, and the mean number of parcels was 5.88 per household, ranging from 1 to 45 parcels. A strong positive aggregated relationship was observed between average landholding area and food-sufficiency level ($R^2 = 0.9224$). Household-level regression analysis further showed that landholding area was positively associated with food sufficiency, whereas family size was negatively associated after controlling for landholding area. The Gini Index of 0.4874 indicated a moderate level of inequality in agricultural land distribution. The findings suggest that improving smallholders' access to productive land, reducing inefficient land fragmentation through appropriate consolidation mechanisms, and strengthening access to irrigation, mechanization, quality seed, and other agricultural inputs can contribute to improved household food security in Nepal's Terai region.

Keywords

Food Security, Agricultural Land, Land Fragmentation, Food Availability, Land Holding

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1. Introduction

Agriculture remains a cornerstone of Nepal's economy and is largely characterized by smallholder farmers who face significant resource constraints [1]. The Terai region accommodates approximately 53.6% of Nepal's total population, with a population density of about 460 persons per km² [2]. It is widely recognized as the nation's food basket due to its significant contribution to agricultural production. However, land distribution remains unequal, with an average landholding of only 0.47 hectares per household, creating challenges for achieving adequate household food sufficiency [3].

Agricultural production and productivity are strongly influenced by land-use patterns [4]. While the demand for agricultural products continues to increase with population growth, the availability of arable land is gradually declining. In countries with limited cultivable land, intensification of agricultural land use can provide an important pathway toward improving food security [5]. Nevertheless, the average size of agricultural landholdings in Nepal continues to decline, which may negatively affect agricultural production and household food availability [6]. Together with population growth and the continued reduction of cultivable land, this trend poses significant challenges to achieving and maintaining household food security [7].

Land fragmentation and the conversion of agricultural land to non-agricultural uses are among the major challenges to sustainable agriculture in Nepal's Terai region [6]. Fragmented agricultural holdings can increase management complexity, constrain irrigation and mechanization, and reduce operational efficiency, thereby affecting agricultural production and household food security [8]. Recent household-level research in Lakshmaniya Rural Municipality further found that greater fragmentation intensity was associated with lower odds of achieving a better food-sufficiency category, whereas larger operated land area was positively associated with food sufficiency [15].

Similar evidence has been reported from Nepal's Middle Hills, where household food sufficiency was positively associated with landholding size, cropping intensity, and agricultural productivity, while larger family size and land fragmentation were negatively associated with food availability [16]. These findings demonstrate that household food sufficiency is shaped by interconnected landholding and demographic factors across different farming systems of Nepal and highlight the importance of examining these relationships in the Terai context. [8].

Nepal's economy depends substantially on agriculture, which makes an important contribution to national GDP, employment, household income, and food supply [9]. Understanding the relationship between agricultural landholding and household food sufficiency is therefore important for assessing food security and developing appropriate intervention strategies. Larger household size generally increases food demand and may negatively affect household food sufficiency,

particularly where agricultural land and productive resources are limited [10].

Land fragmentation is particularly prevalent in the Terai region [6]. Recent evidence from Lakshmaniya Rural Municipality confirms substantial household-level fragmentation and demonstrates its relationship with food sufficiency [15]. Examining landholding and fragmentation patterns can therefore provide useful evidence for developing policies aimed at improving agricultural land management and household food security. The Land Use Regulation, 2022 restricts the subdivision of agricultural land in the Terai region below 675 m² [11], highlighting the importance of maintaining viable agricultural holdings.

This study provides empirical evidence on agricultural landholding, family size, parcel fragmentation, and household food sufficiency in Lakshmaniya Rural Municipality. While previous research in the study area emphasized household-level fragmentation and the potential role of land consolidation [15], the present study focuses on the relationship of landholding area and family size with the duration of household food sufficiency. The findings can support local-level agricultural land-management and food-security policies and contribute to efforts toward achieving Sustainable Development Goal 2 (Zero Hunger). The specific objectives are to analyze household-level landholding patterns, assess household food sufficiency, and examine the relationships of landholding area and family size with household food sufficiency.

2. Methodology

The study focuses mainly on two components of food security at the local level: food availability and access as shown in Figure 1. Household food production is treated as an important pathway to food sufficiency. Agricultural landholding area and family size are considered the main explanatory variables influencing household food sufficiency, measured in months per year. Parcel fragmentation, cropping intensity, irrigation access, fertilizer use, and other farming conditions were also considered as contextual factors influencing agricultural production.

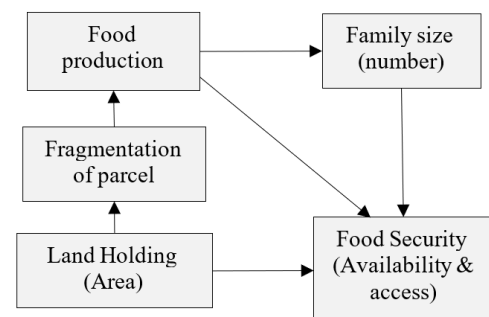


Figure 1. Conceptual Framework.

The overall research process, including primary data collection, statistical analysis, interpretation of findings, and formulation of recommendations, is presented in Figure 2.

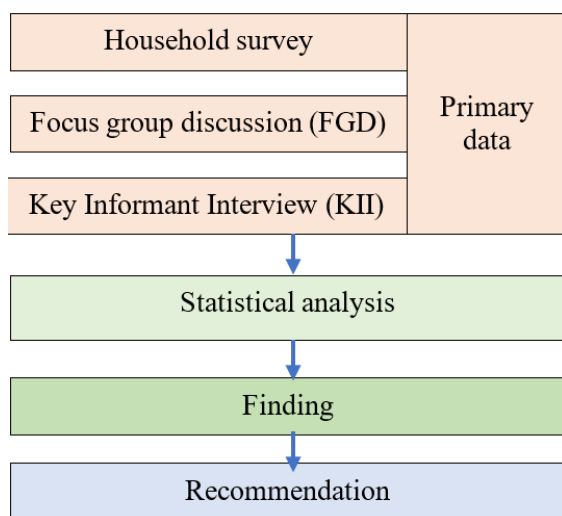


Figure 2. Research Methodology.

2.1. Study Area

Lakshmaniya Rural Municipality is located in Dhanusha District, Madhesh Province, adjacent to Janakpur Sub-metropolitan City. According to the 2021 Population Census, the municipality has a total population of 31,881, with 6,301 households, a literacy rate of 61.60%, a population density of 1,040 persons per km², and a total area of 30.66 km². Agriculture is the predominant occupation [2].

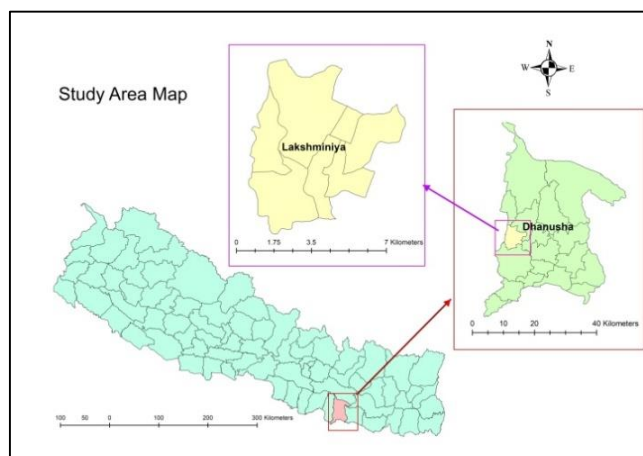


Figure 3. Study area map of Lakshmaniya Rural Municipality, Dhanusha, Nepal.

2.2. Data Collection

Primary data were collected through 396 household questionnaire surveys, two focus group discussions (FGDs), and

four key informant interviews (KIIs). Secondary data from the population census were also used to support the analysis. Cochran's formula [13] was used to calculate the required household sample size at a 95% confidence level, with a Z-value of 1.96, maximum variability ($p = 0.5$), $q = 1 - p = 0.5$, and a 5% margin of error ($e = 0.05$).

$$n_0 = \frac{Z^2 p \cdot q}{e^2}$$

Where

Z = 1.96 (for 95% confidence level)

P = 0.5 (maximum variability)

Q = 1-p = 0.5

e = 0.05 (5% margin of error)

Then

$$n_0 = \frac{1.96^2 \cdot 0.5 \cdot 0.5}{0.05^2} = 384$$

Now

Total number of households (N) = 6301

$$\text{Required number of Sample } (n) = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

$$n = \frac{384}{1 + \frac{384 - 1}{6301}} \approx 362$$

The calculated minimum sample size was 384 households. The total number of households in Lakshmaniya Rural Municipality was 6,301. A total of 396 households were surveyed to account for non-response. The samples were distributed proportionally across all seven wards of Lakshmaniya Rural Municipality, as shown in Figure 4.

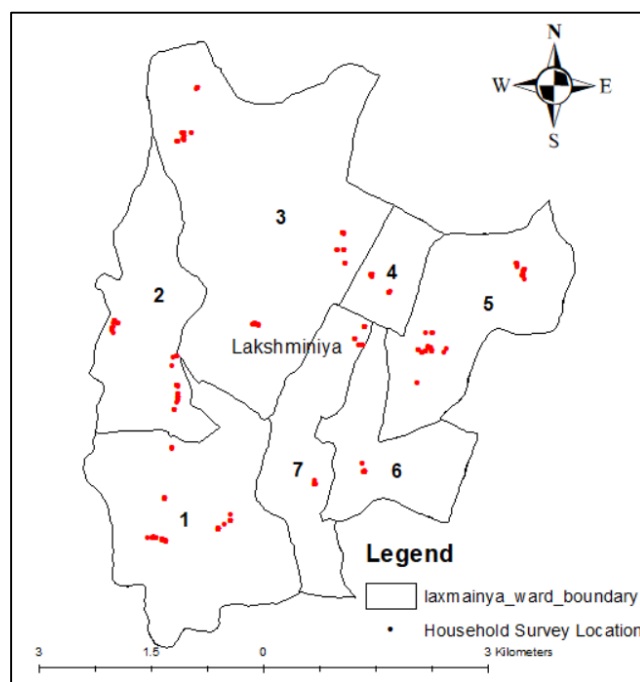


Figure 4. Sample distribution across the seven wards of Lakshmaniya Rural Municipality.

2.3. Variables

The dependent variable in this study is household food sufficiency, measured as the number of months per year for which a household can meet its food needs from its own production. The main independent variables are family size, measured as the number of household members, and agricultural landholding area, measured in hectares. The number of parcels per holding was used as an indicator of land fragmentation. Additional variables collected during the household survey included cropping intensity, irrigation facilities, and chemical fertilizer use. These variables showed limited variability within the study area and were therefore treated mainly as contextual factors rather than as core variables in the final regression model.

2.4. Data Analysis

Household survey coordinates were plotted using GIS. Microsoft Excel and SPSS were used for statistical analysis. Descriptive statistics, including mean, median, mode, frequency, and standard deviation, were calculated, and correlation analysis was performed. A multiple linear regression model was specified with household food sufficiency as the dependent variable and landholding area and family size as explanatory variables:

$$FS = \beta_0 + \beta_1(LH) + \beta_2(FSiz) + \varepsilon$$

where FS is household food sufficiency in months, LH is landholding area in hectares, FSiz is family size, β_0 is the intercept, β_1 and β_2 are regression coefficients, and ε is the error term.

3. Results

3.1. Household Characteristics

Family size ranged from 4 to 12 members, with a mean of 6.9 members and a mode of 6. The average household size in the study area exceeds both the national average of 4.37 and the Terai average of 4.73 [2]. Households with six members formed the largest group (48.99%), followed by households with eight members (32.32%).

Table 1. Household size distribution.

SN	Household size	Frequency	Percentage (%)
1	4	3	0.76
2	5	27	6.82
3	6	194	48.99
4	7	6	1.52

SN	Household size	Frequency	Percentage (%)
5	8	128	32.32
6	9	27	6.82
7	10	8	2.02
8	11	2	0.51
9	12	1	0.25

The household (family) size data in the table can be visualized graphically in Figure 5.

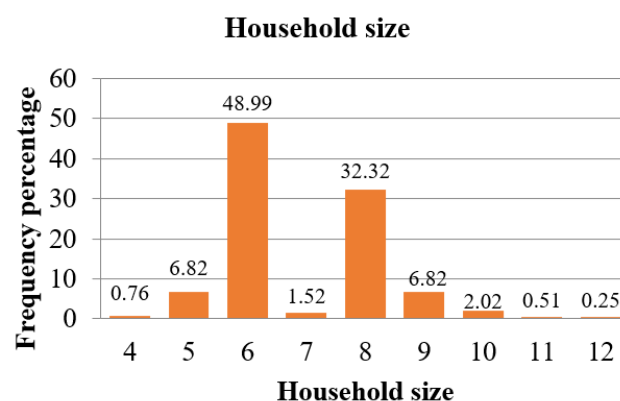


Figure 5. Household size distribution and frequency percentage.

3.2. Landholding and Parcel Fragmentation

Agricultural landholding ranged from 0.034 ha to 10.159 ha, with a mean of 0.785 ha (SD = 0.964). The number of parcels per household ranged from 1 to 45, with a mean of 5.88 parcels (SD = 4.49). For context, national statistics report a mean parcel size of 0.19 ha and an average of 2.8 parcels per holding [12]. The considerably higher number of parcels per household observed in the study area indicates substantial land fragmentation. The summary statistics are presented in Table 2.

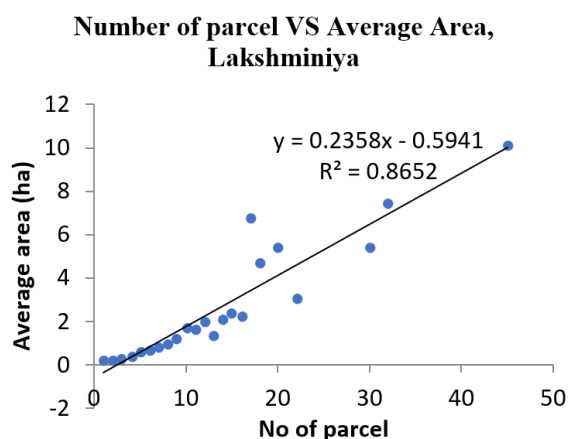
Table 2. Summary of landholding and fragmentation.

Statistics	Land area (ha)	Number of Parcels
Maximum	10.159	45.00
Minimum	0.034	1.00
Average	0.785	5.88
SD	0.964	4.49

Table 3. Average area holding with number of parcels.

No of Parcels	Average Area (ha)	No of Parcels	Average Area (ha)
1	0.172	12	1.964
2	0.174	13	1.355
3	0.291	14	2.145
4	0.440	15	2.370
5	0.594	16	2.269
6	0.656	17	6.773
7	0.797	18	4.741
8	0.990	20	5.418
9	1.253	22	3.048
10	1.693	30	5.418
11	1.609	32	7.450
		45	10.159

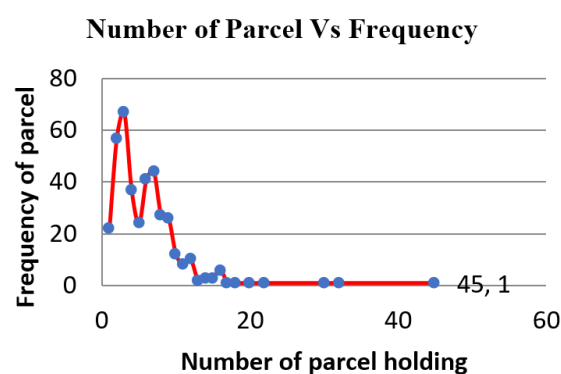
A strong positive relationship was observed between the number of parcels and average landholding area ($R^2 = 0.8652$), indicating that households with larger total landholdings also tended to possess a greater number of parcels (Figure 6).

**Figure 6.** Relationship between number of parcels and average landholding area.**Table 4.** Number of parcels per holding and household frequency.

No of Parcel	Frequency	No of Parcel	Frequency
1	22	13	2
2	57	14	3
3	67	15	3
4	37	16	6

No of Parcel	Frequency	No of Parcel	Frequency
5	24	17	1
6	41	18	1
7	44	20	1
8	27	22	1
9	26	30	1
10	12	32	1
11	8	45	1
12	10		

Figure 7 shows the frequency distribution of parcel numbers. The modal number was three parcels, reported by 67 households. Holdings with 20 or more parcels were uncommon, occurring in only five households.

**Figure 7.** Number of parcels per holding and household frequency.

3.3. Food Sufficiency Status

Food sufficiency was grouped into five categories: three months, six months, nine months, twelve months, and more than twelve months. The percentages in Table 5 are based on 393 valid food-sufficiency responses. Overall, 46.42% of households had food sufficiency for 12 months or more, including 24.94% that reported food sufficiency beyond 12 months. In contrast, 34.86% of households had food sufficiency for six months or less, including 8.91% with only three months of food sufficiency. The average food sufficiency was 9.83 months per year, approximately 10 months.

Table 5. Household food sufficiency.

Food sufficiency (month)	Number of households	Percentage
Three months	35	8.91

Food sufficiency (month)	Number of households	Percentage
Six months	102	25.95
Nine months	72	18.32
Twelve months	86	21.88
More than twelve months	98	24.94

The distribution of household food sufficiency is shown in Figure 8.

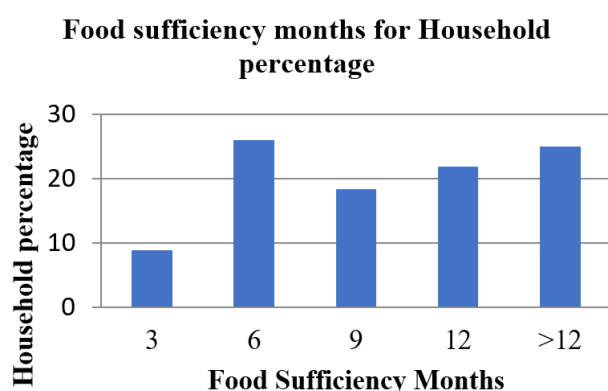


Figure 8. Household food sufficiency.

4. Discussion of the Results

4.1. Landholding Size and Food Sufficiency

A clear positive relationship was observed between average landholding area and household food sufficiency. As food-sufficiency categories increased, the corresponding average landholding area also increased (Table 6).

Table 6. Average landholding area by food-sufficiency level.

Average Land Holding area (ha)	Food Sufficiency Months
0.11	3
0.29	6
0.51	9
0.92	12
1.61	15

A linear fit across the five food-sufficiency groups

produced $R^2 = 0.9224$, indicating a strong positive aggregated relationship between average landholding area and food-sufficiency months (Figure 9). This group-level relationship is consistent with the broader literature showing that land access and land-use conditions are closely related to household food security [8]. The R^2 value here describes the relationship among grouped averages and should therefore be interpreted separately from the household-level regression model presented in Section 4.5.

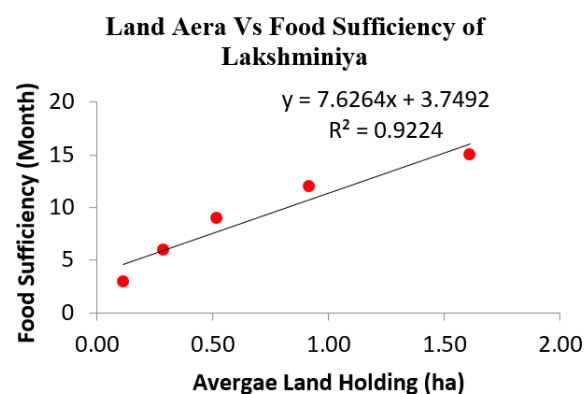


Figure 9. Average landholding area and food sufficiency.

4.2. Parcel Fragmentation and Food Sufficiency

Households in higher food-sufficiency categories also had a greater average number of parcels (Table 7). However, this pattern should not be interpreted to mean that fragmentation itself improves food security. The results in Section 3.2 show that larger landholders tend to own more parcels. Therefore, the positive relationship between parcel number and food sufficiency is likely influenced by total landholding area.

Table 7. Food-sufficiency level and average number of parcels.

Food sufficiency (months)	Average number of parcels
3	1.82
6	3.01
9	4.58
12	6.88
>12	10.33

The findings suggest that land-consolidation measures should primarily aim to improve operational efficiency, while smallholders may require better access to agricultural land, irrigation, and improved production inputs. The relationship between food-sufficiency categories and average parcel number is illustrated in Figure 10.

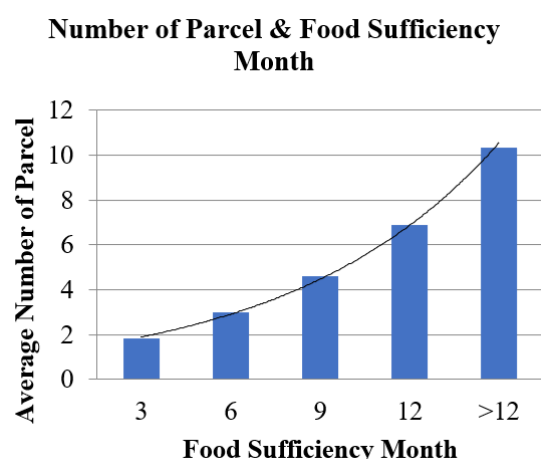


Figure 10. Food-sufficiency level and average number of parcels.

4.3. Family Size and Food Sufficiency

Table 8. Average family size by food-sufficiency level.

Food sufficiency (months)	Average Family size
3	6.42
6	6.80
9	6.50
12	7.18
>12	7.21

The unadjusted group averages in Table 8 show somewhat larger family sizes among households in the higher food-sufficiency categories. This pattern is likely influenced by differences in landholding and other household characteristics. When landholding area is held constant in the multiple regression model, family size has a negative coefficient, indicating that larger households tend to have lower food sufficiency because of greater food requirements. The overall mean family size of approximately 6.9 members is also higher than the national and Terai averages reported in the 2021 census [2].

4.4. Land Distribution Inequality

The Gini Index [14] was used to measure inequality in land distribution among surveyed households. The index ranges from 0 to 1, where 0 represents perfect equality and 1 represents perfect inequality. It is derived from the area between the line of equality and the Lorenz curve; a larger gap indicates greater inequality in land distribution. The estimated Gini Index for land distribution was 0.4874, indicating a moderate level of land ownership inequality among surveyed households. The value shows that land is not evenly distributed and

that some households possess substantially larger landholdings than others. The corresponding Lorenz curve is presented in Figure 11.

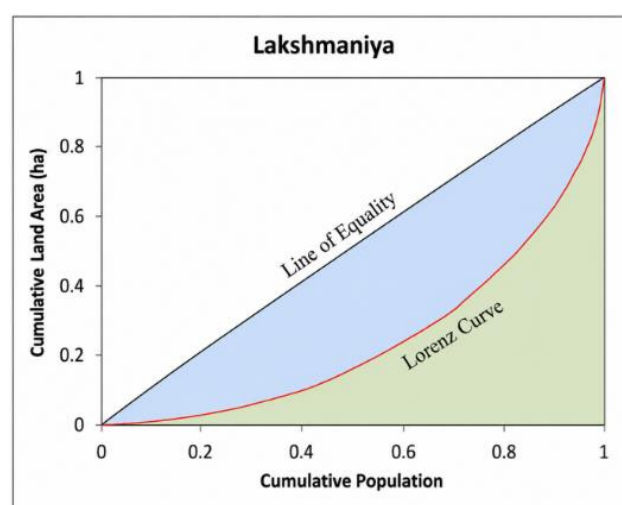


Figure 11. Lorenz curve and Gini Index of land distribution inequality.

4.5. Regression Analysis

A multiple linear regression analysis was performed using data from 387 households, with landholding area and family size as the independent variables and household food sufficiency as the dependent variable. Nine observations with exceptionally large landholdings were excluded from the regression because of their disproportionate influence on the model estimates. This exclusion should be considered when interpreting the results. The estimated regression equation is:

$$FS = 7.21 + 4.82(LH) - 0.26(FSiz)$$

where FS represents household food sufficiency in months, LH is landholding area in hectares, and FSiz is family size. The coefficient for landholding area is positive, while the coefficient for family size is negative. Holding family size constant, a one-hectare increase in landholding is associated with an estimated 4.82-month increase in food sufficiency. Holding landholding area constant, each additional household member is associated with an estimated 0.26-month decrease in food sufficiency.

The overall regression model was statistically significant ($p < 0.05$) at the 95% confidence level. The adjusted R^2 value of 0.51 indicates that approximately 51% of the household-level variation in food sufficiency is explained by landholding area and family size. The predictive performance of the model could be improved in future studies by incorporating additional variables such as land productivity, cropping intensity, irrigation, socioeconomic conditions, and more detailed measures of parcel fragmentation.

4.6. Summary of Key Variables

Table 9 summarizes the main variables derived from the household survey.

Table 9. Descriptive summary of main variables.

Variable	Mean	Std. Dev.	Min	Max
Family Size	6.900	1.320	4.000	12.000
Land Area (ha)	0.785	0.964	0.034	10.150
Number of Parcels	5.870	4.490	1.000	45.000
Food Sufficiency (months)	9.830	3.978	3.000	>12.000

The study area has an average family size of approximately 6.9 members, ranging from 4 to 12 members per household. Landholding area varies widely from 0.0339 ha to 10.15 ha, with a mean of approximately 0.785 ha, reflecting considerable variation in land ownership. The number of parcels ranges from 1 to 45, with an average of approximately six parcels per household. Average household food sufficiency is 9.83 months per year, or approximately 10 months.

4.7. Overall Discussion: Landholding and Food Sufficiency

The household survey, supported by focus group discussions and key informant interviews, indicates that food security remains uneven across the study area. Approximately 8.91% of households were severely food-insecure, with only three months of food sufficiency, whereas 46.42% reported food sufficiency for 12 months or more. The Gini Index of 0.4874 indicates a moderate level of inequality in agricultural land distribution. Approximately 13% of surveyed households held 10 or more parcels, while most households held fewer than 10 parcels.

The descriptive analysis shows that households with a greater number of parcels also tend to have higher food sufficiency. However, this does not imply that fragmentation itself improves food security, because larger total landholdings are also associated with a greater number of parcels. The household-level regression provides a clearer interpretation: landholding area has a strong positive association with food sufficiency, while family size has a negative association after controlling for landholding area. These findings show that both access to agricultural land and household food demand are important for understanding food sufficiency in the study area.

Although the Terai is widely regarded as Nepal's food basket, the results show that household-level food insecurity persists alongside unequal land distribution and fragmented agricultural holdings. Policies that improve access to productive

land, reduce inefficient fragmentation, and strengthen agricultural productivity may therefore contribute to improved food security.

5. Conclusion

The Terai region is widely regarded as Nepal's food basket, yet the findings show that household-level food insecurity persists in Lakshmaniya Rural Municipality. Average household food sufficiency was 9.83 months per year. While 46.42% of households reported food sufficiency for 12 months or more, 34.86% reported six months or less, including 8.91% with only three months of food sufficiency.

Agricultural landholding area was positively associated with household food sufficiency, whereas family size showed a negative association after controlling for landholding area. The study also identified substantial parcel fragmentation, with an average of 5.88 parcels per household and a maximum of 45 parcels, while the Gini Index of 0.4874 indicated moderate inequality in agricultural land distribution.

These findings support modernization and commercialization of agriculture together with improved access to productive land for smallholder farmers, including locally appropriate mechanisms such as land banking where feasible. Policies should also reduce inefficient fragmentation through suitable land-consolidation approaches, improve irrigation and mechanization services, ensure timely access to quality seed and other production inputs, and control unnecessary conversion of productive agricultural land to non-agricultural uses. Such measures can strengthen agricultural productivity, improve equitable access to productive resources, and enhance household food security in the Terai.

Abbreviations

FGD	Focus Group Discussion
KII	Key Informant Interview
GIS	Geographic Information System
SPSS	Statistical Package for the Social Sciences
FS	Food Sufficiency
LH	Landholding Area
FSiz	Family Size
GDP	Gross Domestic Product
SDG	Sustainable Development Goal

Author Contributions

Tanka Prasad Dahal: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft

Reshma Shrestha: Formal Analysis, Methodology, Validation, Writing – review & editing

Purna Bahadur Nepali: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing

Bhuwan Singh Bisht: Data Analysis, Methodology, Validation, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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